remembered. If we turn to the coal burnt per hour per square foot of heating surface we find it but 0·298 lbs. in the *Iona*, and 1·01 lbs. in the *Ville de Douvres*. With regard to evaporation, each square foot of heating surface in the *Iona's* boilers turned 2·73 lbs. of water into steam per hour; in the *Ville de Douvres* the corresponding figure was 9·02. The feed-water evaporated per lb. of fuel was 9·15 lbs. in the *Iona*, and 8·97 lbs. in the *Ville de Douvres*. Taking carbon values—that is, excluding incombustible ash—and reducing the results to an equivalent of evaporation from and at 212°, we find the corresponding figures to be 10·42 lbs. for the *Iona* and 9·94 lbs. for the *Ville de Douvres*, a by no means bad result for the latter vessel's boilers, considering the demand made upon them in other respects.

Turning to the engines of these two ships, we find that the efficiency of the *Iona's* engines was 17·1 per cent., whilst the *Ville de Douvres'* engines had an efficiency of 11·7 per cent. The weight of steam used in the main engines of the former vessel was 13·35 lbs. per indicated horse-power per hour, whilst in the *Ville de Douvres* there were required 20·77 lbs. of steam to produce one unit of power.

The figures we have quoted will be sufficient to give an idea of the scope of the paper. We have not space to go into the discussion upon the various causes of the variations in results; for these we must refer our readers to the Proceedings of the Institution, where also will be found an account of the long and interesting discussion which followed the reading of the paper.

The summer meeting will be held this year in Manchester, at the beginning of August.

ON THE MOTION OF BUBBLES IN TUBES.

EVERY student of physics has observed the motion of bubbles in tubes. Which of them has not used a big bubble to show the little ones their duty in clearing out the air when filling a barometer tube? Who has not spent his time and patience in whisking a spirit thermometer to drive a bubble out of the column? Mr. Trouton has recently communicated to the Royal Society the result of some researches on this subject. He has studied the behaviour of big bubbles and of little ones, of bubbles in large and small tubes, of bubbles of air in a liquid, and of one liquid in another, of bubbles in heavy and in light liquids, of bubbles in liquids of various degrees of viscosity and with various degrees of surface tension at their surfaces. From this enumeration it is evident that the number of different magnitudes involved is very great, and at the start it seemed almost hopeless to disentangle the effects due to each. The first matter to observe was that, as in other cases of fluid motion, two cases must be distinguished. These are the cases of slow motion and of quick motion. When the motion is slow the viscosity of the liquid causes the flow to be very simple. It entirely stops all whirling and swirling, such as is seen in the water behind a boat. When the motion is quick, on the other hand, the flow is very complicated. Whirls and swirls are set up, and the resistance is increased, owing to the increased energy that has to be communicated to the whirling and swirling liquid for each centimetre that the bubble moves. The slow kind may be described as viscous flow, and the quick as turbulent flow. The most interesting point observed in connection with the turbulent flow was that it was sometimes possible to *increase* the rate of flow by *increasing* the viscosity. Increasing the viscosity of a liquid generally makes it flow more slowly, but in some critical cases the increase of viscosity may produce more effect in decreasing the turbulence than in increasing the viscous resistance, and the result is to, on the whole, reduce the combined resistance so that the bubble moves more rapidly in the liquid of greater viscosity. Another matter that was of interest was the question of the size of the bubbles, and how it affected their rate of motion. Very long bubbles moved all at nearly the same rate, but short bubbles had a great variety of rates. Very small bubbles ran along ever so fast, while ones only a little larger went very much more slowly. These latter blocked up the tube much in the same way that a crowd blocks its own egress through a doorway. However, bubbles a little larger seemed to have more sense, for they shape themselves into a sharpish head, with the result that they can make their way along the tube more rapidly than smaller ones. Those a little larger again take up a dumb-bell sort of shape, and block the tube, and go more slowly again, though not so slowly as the smaller blocking bubbles. A little larger go somewhat more rapidly again, but as the bubbles are made longer the differences between the rates of the quick and slow sizes become rapidly less and less until pretty soon all go at the same rate, no matter how long they are. This alternation of speeds is evidently connected with the ripples that are formed at the head of the bubble as it passes through the liquid, much as a stick moving through water makes a series of ripples upon the surface. If the ripples are so long that the bubble has a pointed head it goes fast, if it has a blunt head it goes slowly. These ripples are in some cases very marked. Mr. Trouton found that when a bubble of oil was allowed to rise through water with which one fifty-thousandth part of caustic soda was mixed the ripples became quite a feature of the figure of the bubble. They at first extended as a series of rings round it, which, however, soon coalesced into a spiral wave, when the bubble rose rapidly through the liquid with a sort of corkscrew motion. If the tube were inclined the ripples were only formed on the lower surface of the bubble, the top surface floating up against the containing tube, and the ripples then looked like the feet of a caterpillar walking up the tube. This is not the only case in which surface tension motions simulate muscular actions, and it is an important question whether some of these actions are similarities or simularities.

The surface tension between the air and liquid if the bubble is an air bubble, and between the two liquids if the bubble is a liquid one, has a very important bearing on the rate of motion of the bubble, for it is owing to this surface tension that the bubble swells out and presses against the sides of the tube. In consequence of this, when the surface tension is large the bubble moves more slowly than with a small surface tension. It would take too long to explain all the considerations by which Mr. Trouton was led to conclude, by the dimensions involved, that the velocity could be expressed in a series of powers of $S/g\delta D^2$ when S is the surface tension, g the acceleration of gravity, δ the difference of density of the liquid and bubble, and D the diameter of the tube. This series is multiplied by $\mu/g\delta D^2$ where μ is the viscosity of the liquid. Two assumptions are made. First, that the viscosity of the material of which the bubble is made is negligible; and secondly, that the motion produced by the surface tension is negligible compared with the motion produced by gravity. The series he gets from his experiments represents the results as accurately as can be expected, considering that the bubbles varied in density from air to mercury, the viscosity of the liquid from 1 to 833, and the surface tensions from 2 to 370. The series Mr. Trouton gives for calculating the time, T, a bubble takes to move one centimetre is

$$T = \frac{A_1\mu}{g\delta D^2} + \frac{A_2\mu S}{g^2\delta^2 D^4} + \frac{A_2\mu S^2}{g^3\delta^3 D^6}$$

The values of the constants can be determined by the values he gives from experiments on glycerine whose density was 1·25 and superficial tension 63 dynes per centimetre.

$$\frac{A_1\mu}{g} = 1{\cdot}308, \quad \frac{A_2\mu}{g^2} = {\cdot}02322$$

and

$$\frac{A_3\mu}{g^3} = {\cdot}0009108.$$

The formula is unfortunately a very inconvenient one for using to calculate the quantity that enters into it, and which is the most difficult to determine, namely, the surface tension between the bubble and liquid. This method of determining surface tension is one of the very few by which it can be determined without knowing angles of contact, which are so very difficult to determine at all accurately. In this way Mr. Trouton has determined the initial surface tension to be 6·5 between a bubble of water and glycerine that was pretty rapidly dissolving it. The ripple method could hardly be applied to this case, and it is doubtful whether the jet method could be applied to the surface between two liquids.

In connection with the high power to which g is raised in the formula it is interesting to note how, by altering the acceleration on the liquid by impacts or by centrifugal force we can very much increase the rate at which a bubble passes along a tube. This seems to be part of the rationale of the methods by which a bubble in a spirit thermometer can be shaken or whirled up the column.

The whole subject is of considerable interest, and lends itself to experimental investigation with very simple apparatus. A

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few glass tubes and the liquids to be experimented with are almost the only things required in addition to a plentiful supply of care in cleaning. An investigation of the problem from purely dynamical considerations might well tax the powers of an ambitious mathematician, and provide tripos problems for many years.

SCIENCE IN THE MAGAZINES.

THE *Fortnightly* again takes the first place, as regards scientific articles, in the magazines received by us. Mr. Herbert Spencer contributes to it a paper on the late Prof. Tyndall, Prof. Karl Pearson writes on "Science and Monte Carlo," and Mr. H. O. Forbes states the grounds of his belief in "Antarctica: a Vanished Austral Land." Mr. Spencer does not dwell upon the more conspicuous of Prof. Tyndall's intellectual traits, but upon a few characteristics concerning which little has been said. Chief among these powers of thought was "the scientific use of the imagination." Tyndall insisted upon the need for this. "There prevail, almost universally," Mr. Spencer points out, "very erroneous ideas concerning the nature of imagination. Superstitious people whose folk-lore is full of tales of fairies and the like, are said to be imaginative; while nobody ascribes imagination to the inventor of a new machine . . . . strange as the assertion will seem to most, it is nevertheless true that the mathematician who discloses to us some previous unknown order of space-relations does so by a greater effort of imagination than is implied by any poetic creation." The faculty with which Tyndall was largely endowed was that of constructive imagination, and he used that talent in all his work. Among other points upon which Mr. Spencer dwells in the eulogy of his dead friend, are Tyndall's intellectual vivacity, and the x Club described by Prof. Huxley. The influence that the Club eventually exercised in the scientific world is shown by the fact that it contained four presidents of the British Association, three presidents of the Royal Society, and presidents of the College of Surgeons, of the Mathematical Society, and of the Chemical Society. The number of members is now reduced to five, and the Club is practically dead. The object of Prof. Pearson's essay is to show that chance as it applies to the tossing of an unloaded coin has no application in Monte Carlo roulette. The discussion of records of the roulette tables leads to the strange result that "the random spinning of a roulette manufactured and daily readjusted with extraordinary care is not obedient to the laws of chance." In the *Fortnightly* of May last, Mr. Forbes gave reasons for believing that "there must have existed in the Southern Seas an extensive continuous land similar to that in the Northern Hemisphere, on which the common ancestors of the forms unknown north of the equator, but confined to one or more of the southern extremities of the great continents, lived and multiplied, and whence they could disperse in all directions." He then remarked that this lost continent "lies in part beneath the southern ice-cap, and it approached to, or included, the Antarctic Islands, as well as extended northward to unite with the southern extremities of South America, perhaps with Africa, and with the Mascarene, the Australian, and the New Zealand continental islands." Mr. Forbes now brings forward a mass of evidence in support of his view, dealing in detail with the distribution of different divisions of the animal kingdom.

The *Century* contains a biographical sketch of Mr. Nikola Tesla, by Mr. T. C. Martin, illustrated by an excellent portrait of that investigator. Mr. Tesla comes of an old Servian stock, and is but thirty-six years of age. His electrical work began in the Polytechnic School at Gratz, where he distinguished himself in experimentation. He afterwards became an assistant in the Government Telegraph Engineering Department at Buda-Pest, from which he passed into an electric-lighting establishment in Paris. A little later he crossed the Atlantic, and entered one of Mr. Edison's workshops. When his term of apprenticeship there had ended, he struck out for himself, his investigations eventually leading him to the brilliant phenomena produced with currents of high potential and high frequency. "Recently," says Mr. Martin, "the high-frequency generators with which he had done so much of this advanced work have been laid aside in discontent for an oscillator, which he thinks may not only replace the steam-engine with its ponderous fly-wheels and governors, but embodies the simplest possible form of efficient mechanical generator of electricity."

Orchid lovers—and who are not lovers of those marvellous plants?—will find pleasure in reading an article on "Orchids," contributed by Mr. W. A. Styles to *Scribner*. The article is embellished by M. Paul de Longpré, with fourteen illustrations of the beautiful and fantastic forms of orchid flowers. Mr. Styles gives an account of a collector, who, when offering his plants for sale, explained that they had a special value, inasmuch as he had taken pains to destroy all that remained in their native woods. "This ingenuous avowal," continues Mr. Styles, "suggests a new danger to the orchid supply. It has already been necessary to pass laws in Switzerland to protect the endelweiss from tourists; there are societies in many European countries to rescue rare and native plants from extinction by amateur botanists and others. In our own country a few extremely local ferns and wild flowers are already in danger of extermination, and in the case of certain species of orchids of a limited range, each one of which has a money value regulated by the scarcity of the plants, the greed of man furnishes a motive for the wholesale destruction of all which cannot be carried away. The beautiful *Disa grandiflora* has already become scarce on Table Mountain, and the authorities at the Cape of Good Hope have found it necessary to forbid collecting it in order to prevent its total destruction. Rajah Sir Charles Brooke, of Sarawak, in Borneo, has issued an order to forbid the collection of plants in the country under his control, and if restrictions like this come to be enforced throughout the tropical regions tributary to the British Empire, it will cause consternation among the importers, who are receiving more than half a million orchids every year." *Scribner* also contains a striking article by Mr. J. C. Harris, on the terrible storm that devastated the Sea Islands and the coast of the United States from Charleston to Savannah last August.

A long discussion of Sir Henry Howorth's "Glacial Nightmare" appears in the *Quarterly Review* (No. 355). In conclusion the reviewer remarks: "We venture to record the opinion that in his treatment of the rival claims of ice and of water, as to which was the chief factor in producing the great Drift at the close of the Pleistocene epoch, our author has succeeded in shifting the balance of probability, and transferring it to the action of the latter."

Among other contributions of scientific interest in the magazines received by us is an interview with Dr. A. R. Wallace, F.R.S., on "Heredity and Pre-natal Influence," published in the *Humanitarian*; an article in *Longman's*, in which Mr. J. G. McPherson brings together a number of elementary facts relating to "Colour," and a paper on "Vegetable Monsters," by Mr. Edward Step, in *Good Words*. Mr. Step describes the current fictions concerning the so-called Devil-tree, the Upas-tree, the manchineel (*Hippomane mancinella*), and the Scythian Lamb (*Agnus Scythicus*). We have received the *Contemporary*, but it does not contain any articles on scientific topics.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The voting for the board of the Faculty of Natural Science last week resulted in the election of Messrs. J. E. Marsh, H. Balfour, A. G. Vernon Harcourt, W. Esson, G. C. Bourne, and R. E. Baynes. Mr. R. H. Bremridge has been elected to a Senior Demyship at Magdalen College. Mr. Bremridge obtained a first class in the Honour School of Natural Science (Physiology) last year. Mr. R. T. Günther has been chosen as science tutor at Magdalen College, to succeed Mr. E. Chapman, who is leaving Oxford at the end of the Summer Term.

Professor Ray Lankester is issuing a volume of studies made in the Linacre Department since his election to the Professorship. The volume, which bears on its cover a medallion with a likeness of Linacre, contains papers by Dr. W. B. Benham, and Messrs. Minchin, R. T. Günther, Goodrich, Pycraft, and others.

CAMBRIDGE.—The electors to the Downing Professorship of Medicine, vacant by Dr. Latham's resignation, will meet for the purpose of electing his successor on March 3. Candidates are to send twelve copies of their testimonials (if any) to the vice-chancellor (the Rev. A. Austen Leigh, Provost of King's) by Monday, February 26.

The Council of the Senate have published, in the *Uni-*

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